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A RAND NOTE

SDI and the Soviet Defense Burden

Gregory G. Hildebrandt

December 1988

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The Soviets' response to the Strategic Defense Initiative (SDI) must be understood within the context of their deteriorating economic situation and need to modernize their economy. This Note evaluates the defense burden to the Soviets of both an offsetting and an emulation response to the U.S. SDI effort. The analysis is conducted within the context of General Secretary Gorbachev's modernization program, which is designed to increase the productivity of economic resources. The analysis suggests that the Soviets can partially offset a U.S. SDI effort with a ruble expenditure that is a small percentage of current defense spending. Although the Soviets may regard such a response as unsatisfactory, it is important to consider the striking contrast compared with the burden of an emulation response. The author hypothesizes, therefore, that the Soviets will choose not to directly emulate the U.S. SDI activities, at least until they have modernized their technical-economic base.

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PREFACE

The RAND Corporation is providing analytical support to the Assistant Chief of Staff/Intelligence, Hq. USAF, on the question of possible Soviet responses to the U.S. Strategic Defense Initiative (SDI). This effort examines Soviet policy toward SDI in terms of doctrine and strategy, offensive and defensive force deployments, internal resource decisions, arms control behavior, and international conduct that could have a bearing on U.S. security. Although it necessarily includes consideration of Soviet R&D trends related to SDI, it does not principally aim to do technological forecasting, nor does it intend to compete in any other way with the many technical assessments of Moscow's response options already underway, both within and outside the U.S. government. Rather, it is mainly concerned with political-military issues and seeks to explore the implications of SDI for Soviet foreign and defense policy more broadly defined.

This Note evaluates the defense burden to the Soviets of both an offsetting and an emulation response to the U.S. SDI effort. This analysis is conducted within the context of General Secretary Gorbachev's modernization program, which is designed to increase the productivity of economic resources.

This Note should be of particular interest to USAF officers in both the IN and XO communities concerned with SDI, U.S.-Soviet strategic interaction, the arms control process, and trends in Soviet military doctrine and policy.

The work was conducted under the project entitled "Soviet Responses to the U.S. Strategic Defense Initiative" for the National Security Strategies Program of Project AIR FORCE.



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SUMMARY

The Soviet response to SDI must be understood within the context of their deteriorating economic situation and need to modernize their economy. General Secretary Gorbachev has initiated a program to intensify the industrial base with large infusions of resources into machine tools, electronics, and computers.

Two approaches are used in this study. In one approach, we build on an analysis of the marginal cost exchange ratios associated with a Soviet offsetting response to a U.S. SDI program. **For a case in which the U.S. SDI program is a \$500 billion Rocket Propelled Interceptor program, we find that the Soviets can partially offset the U.S. program for about 45 billion rubles by proliferating reentry vehicles (warheads).** By increasing the production of SS-18s and SS-19s, a Soviet first strike with 24,000 reentry vehicles would destroy about 40 percent of the U.S. target base.

Although we estimate that the annual cost of this offsetting response would only represent a small fraction of current defense spending, careful analysis is required before determining what effect this would have on the strategic balance. For example, although the Soviets are estimated to regain a considerable amount of first-strike capability through this type of response, they might also perceive that the U.S. SDI system has seriously diminished their second strike capabilities.

Our second approach assumes a Soviet emulation response to the U.S. \$500 billion SDI effort. We estimate that the cost to the Soviets of such a response would be about 300 billion 1982 rubles. **If we assume that Gorbachev's economic modernization program is not successful, possibly because of competition with a Soviet SDI effort, such expenditures could cause per capita consumption to decline.** The Soviets would also increase the defense burden by an average of about 1.5 percentage points per year while their SDI program is underway. **If the Gorbachev modernization program is reasonably successful at the same time as a Soviet 300 billion ruble emulation response occurs, however, per capita consumption can continue to rise.**

At the very least, we can expect the Soviets to be concerned with the possibility that an emulation response will undermine the modernization program. It may be reasonable, therefore, to hypothesize that the Soviets will choose not to directly emulate

the U.S. SDI activities until they have had an opportunity to modernize the technical-economic base. Rather, they might initially attempt to offset the U.S. effort. The uncertainties associated with these types of calculations indicate that this hypothesis should be evaluated through a detailed analysis of the Soviet technological constraints and opportunities.

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Abraham Becker, Arnold Kanter, and Steven Popper contributed many helpful comments on an earlier draft. The outstanding secretarial support of Jean Williams is also appreciated.

CONTENTS

PREFACE	iii
SUMMARY	v
ACKNOWLEDGMENTS	vii
FIGURES AND TABLE	xi
Section	
I. INTRODUCTION	1
II. MILITARY-ECONOMIC CONTEXT	5
Strategic Spending and Military Burden	5
Economic Slowdown and Emerging Policies	6
Predicting Soviet Economic Performance	9
III. COST METHODOLOGY	17
IV. OFFSETTING RESPONSE	19
V. EMULATION RESPONSE	26
VI. CONCLUSIONS	32
APPENDIX	35

FIGURES

1.	Soviet GNP and TFP growth with constant capital productivity, 1990-2010	12
2.	Soviet GNP growth, 1990-2010	13
3.	Soviet per capita consumption growth, 1990-2010	14
4.	Alternative Soviet GNP growth, 1990-2010	15
5.	Soviet growth alternatives, 1990-2010	16
6.	U.S. defense cost vs number of RPI in orbit	20
7.	Rocket-propelled interceptor defense effectiveness for various U.S. SDI cost and deployment assumptions	21
8.	Soviet attack cost vs attack size	22
9.	Cost of Soviet offsetting response to SDI, 1990-2010	24
10.	Alternative Soviet defense spending patterns	28
11.	Soviet GNP, 1990-2010	28
12.	Soviet per capita consumption, 1990-2010	29
13.	Alternative Soviet GNP, 1990-2010	30
14.	Alternative Soviet per capita consumption, 1990-2010	31
A.1.	Soviet aggregate economic model	35

TABLES

1.	Ruble-dollar ratios	17
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I. INTRODUCTION

The Soviet military strategy that evolves in response to the U.S. Strategic Defense Initiative (SDI) will be affected by specific economic constraints as "mediated by military doctrine." Military doctrine will be shaped by political and foreign policy factors as well as the level of current and expected military technology. Broad economic considerations may also affect the evolution of this doctrine.

Historically, one of the most stable elements of Soviet military strategy has been the *principle of homeland defense*. During the 1970s, the dollar cost of Soviet strategic air defense activities was several times the dollar cost of U.S. strategic bomber activities.

The homeland defense principle is not incompatible with an offensive military strategy. Indeed, for an offensive strategy to be viable, it may be necessary to be able to protect one's territory from strategic attack. Recently, the Soviets have begun to develop a new military doctrine called "reasonable sufficiency." How this new doctrine will affect military strategy in either the conventional or strategic area is not clear at the present time; it may only further promote the homeland defense principle.

In light of SDI, which itself is a clear example of a homeland defense system, it is appropriate to evaluate the cost of several possible Soviet responses to it. Soviet planning procedures stipulate that cost should be accounted for during military planning. The Soviet response to the U.S. effort will no doubt depend, in part, on the cost of the alternatives.¹

¹The relationship between military doctrine and military strategy in the Soviet Union is discussed in Stephen Meyer, *Soviet Theater Nuclear Forces: Part I: Development of Doctrine and Objectives*, Adelphi Paper No. 187, International Institute for Strategic Studies, Winter 1983. David Holloway has discussed how the effect of economic considerations on defense policy is "mediated by military doctrine," and also how these considerations can influence military doctrine in *Defense Policy and the Soviet Economy*, unpublished draft, 1983. He has also discussed the consideration given to cost in Soviet military planning in "Economics of the Soviet Weapons Acquisition Process," *Soviet Military Economic Relations*, Proceedings of a workshop on July 7 and 8, 1982, sponsored jointly by the Subcommittee on International Trade, Finance, and Security Economics of the Joint Economic Committee and the Congressional Research Service, Library of Congress, Washington, D.C., 1983, pp. 25-52. A discussion of reasonable sufficiency is contained in *Gorbachev's Economic Program: Problems Emerge*, a report by the Central Intelligence Agency and the Defense Intelligence Agency, presented to the Subcommittee on National Security Economics of the Joint Economic Committee, April 13, 1988, p. 21. The principle of homeland defense in Soviet strategy and the relationship between this principle and the Soviet response to SDI are discussed in

This study estimates the ruble cost to the Soviets of two canonical responses to SDI. In the "offsetting response," the Soviets attempt to counter the U.S. strategic defense effort by expanding existing strategic offensive forces. This expansion is assumed to take the form of an increase in the number of reentry vehicles (warheads) used in an attack on the United States.

The second canonical response, called the "emulation response," assumes that the Soviets will deploy an SDI system that is comparable (or "essentially equivalent") to the U.S. system. Such a Soviet response may have an important relationship to General Secretary Gorbachev's economic modernization program, which is designed to halt the decline in Soviet economic performance by increasing the productivity of the manufacturing process. The extent to which this modernization program is actually a precondition for a Soviet emulation response is not well understood and awaits further analysis. However, if an emulation response is feasible, it will sufficiently tax the scarce high-technology resources of the economy so as to compete with the modernization program.²

To estimate the domestic cost of the two Soviet responses, the dollar cost of each is converted into rubles using ruble-to-dollar ratios for broad expenditure categories. These ratios measure the domestic cost to the Soviets of a dollar's worth of some activity. Clearly, the higher the ruble-to-dollar ratio, the less efficient the Soviets are (relative to the United States) in producing some good. Therefore, that ratio provides a measure of Soviet comparative advantage in the production of some good.

Ideally, one would hope to be able to develop these ratios for specific program alternatives. Data limitations, however, necessitate the use of aggregate ratios that reflect technological and capacity restraints in a very general fashion.

Benjamin Lambeth and Kevin Lewis, *The Strategic Defense Initiative and Soviet Planning and Policy*, The RAND Corporation, R-3550-AF, January 1988. The dollar cost of Soviet strategic defense and U.S. strategic bomber activities is discussed in *Soviet and U.S. Defense Activities, 1971-1980: A Dollar Cost Comparison*, CIA, SR 81-10005, January 1981, pp. 3-8.

²The modernization program is discussed in Douglas Kershover, "Gorbachev and the Economy: The Developing Gameplan," in *Gorbachev's Economic Plans: Volume 1*, study papers submitted to the Joint Economic Committee, Congress of the United States, November 23, 1987, pp. 54-69. Stephen Meyer has discussed the concepts of an offsetting and emulation response in "Soviet Strategic Programmes and the US SDI," *Survival*, Vol. 27, No. 6, Nov/Dec 85.

Some background information on strategic spending as a percent of total military spending and military spending as a percent of GNP provides a better understanding of the context within which the Soviet response takes place. The issue of specific constraints that bear on defense activity is also discussed, followed by a summary of the broad features of General Secretary Gorbachev's economic policy.

Next, economic performances are forecast for two scenarios. In one, the Soviet experience over the last decade is used to forecast economic performance between 1990 and 2010; in a second scenario, it is assumed that the modernization program results in a moderate increase in the productivity of economic resources.

After this background discussion, an estimate of the cost to the Soviets of an offsetting response to an SDI program is developed. Although there are several offsetting responses that might be considered, to demonstrate the methodology, this Note focuses on the effect of an increase in the number of Soviet reentry vehicles (RVs).³

The extent to which these additional RVs are successful in penetrating several U.S. levels of SDI effort and the incremental destruction of the U.S. target base are estimated. For a wide range of levels of U.S. SDI activity, it is possible to relate the fraction of the U.S. target value attacked that survives to the size of the Soviet attack. Then, by associating the Soviet attack size with an estimate of its ruble cost, one can obtain an estimate of the economic burden to the Soviets of this type of offsetting response.

For Soviet emulation, it is assumed that the Soviets deploy a system of comparable size to that of the United States. The cost of such a program in rubles is calculated as is the effect of this increase in Soviet defense spending on per capita consumption and GNP.

There are many uncertainties associated with the types of calculations presented in this study. The analysis should be viewed as illustrative of the type of methodology the Soviets might use to evaluate their alternatives. The entire construct presented should not be taken literally. Its major purpose is to bring into focus several of the following types of issues associated with the Soviet response to a U.S. SDI program: Will the

³Benjamin Lambeth and Kevin Lewis in *The Strategic Defense Initiative in Soviet Planning and Policy* discuss many of the Soviet alternatives. These include SDI suppression measures, active measures to penetrate or end-run SDI, and passive measures to maintain Soviet retaliatory force penetrativity. The latter category includes the much discussed fast-burning ICBMs, which would minimize exposure time during the boost phase of flight.

Soviets attempt to offset SDI, or will they emulate the program? What are the relative costs of each response, and how are these costs affected by differences in Soviet efficiency in producing high and low technology defense goods? Furthermore, how do these costs relate to the Gorbachev modernization program? Is that program a precondition for a high technology defense effort; or if not, might not the program be competitive with such a defense effort? What is the nature of the tradeoffs between a high technology defense effort and consumption, investment, and defense? How are these tradeoffs affected by the productivity enhancements the modernization program is attempting to achieve?

This study does not fully answer these questions, but may provide a useful framework for those who are involved in conducting the detailed case analysis of these issues. Although such analysis has yet to be accomplished, it must ultimately be undertaken to answer these types of questions.

II. MILITARY-ECONOMIC CONTEXT

STRATEGIC SPENDING AND MILITARY BURDEN

Although the shares of Soviet ruble outlays allocated to the Strategic Rocket Forces and National Air Defense (PVO) fluctuated modestly between the mid-1960s and mid-1970s, the strategic mission consumed some 20–23 percent of total Soviet defense expenditure during the period. Beginning about 1977, however, the shares of defense expenditure going to the strategic mission may have declined somewhat as the total outlays of the Strategic Rocket Forces and National Air Defense Forces declined in absolute terms.

Since 1977, the rate of growth of total spending in all Soviet military services has declined as defense activity growth has been reduced from its historical level of 4–5 percent a year to about 2 percent. The growth of procurement expenditures during this period was fairly flat, though there are some indications that the growth of this major category of military investment began to increase around 1984.

There are considerable uncertainties concerning whether the slowdown in spending growth and in the share allocated to strategic forces resulted from economic constraints or from a policy change. However, a rise in the cost of Soviet defense activities has increased the defense burden from 12–14 percent of GNP in 1970 to about 15–17 percent of GNP in 1982 when this indicator is measured in the prices of the respective years.¹

¹Soviet defense spending by service is discussed in *Estimated Soviet Spending: Trends and Prospects*, CIA, SR 78-10121, June 1978. The Strategic mission share is provided in *Soviet and U.S. Defense Activities*. A discussion of the slowdown in Soviet defense spending is provided in the *Statement by Robert Gates*, Deputy Director for Intelligence, Central Intelligence Agency, on the Allocation of Resources in the Soviet Union and China—1984, before the Subcommittee on International Trade, Finance, and Security Economics of the Joint Economic Committee, U.S. Congress, November 21, 1984. The issue of whether the defense spending growth slowdown resulted from economic constraints or from a policy change is also discussed in this statement. The change in the defense burden over time is discussed in *Gorbachev's Modernization Program: A Status Report*, a paper presented by the Central Intelligence Agency and the Defense Intelligence Agency for submission to the Subcommittee on National Security Economics of the Joint Economic Committee, Congress of the United States, 19 March 1987, p. 15.

The share of GNP allocated to defense reflects the most general type of resource constraint. This share is called "the burden of defense spending," although it is important not to impute more meaning to the term "burden" than appropriate. "Defense burden" is only a summary measure of the proportion of total resources devoted to defense activities. It contains information about the nature of the general resource constraint that limits the expansion of military spending over the long run. It also provides a rough estimate of the quantity of nondefense goods being forgone as a result of the defense activities.

As one shortens the planning horizon, specific resource constraints have greater influence on the available alternatives. These constraints apply when the supply of certain production or resource capacities is limited. The specific constraints have been applicable to such areas as the production of major surface combatants when shipyards have a limited capacity and expansion can only take place slowly.

There are additional specific constraints that affect the relative costs of the different force-structure alternatives. For example, the degree to which production technologies are similar between the military and civilian sectors influences the transferability, and therefore the costs, of defense expansion.

ECONOMIC SLOWDOWN AND EMERGING POLICIES

The Soviet response to SDI may take place in an uncertain economic environment. Since the mid-1970s, there has been a marked slowdown in productivity growth as the economy has had to contend with a decline in investment growth, unexpected energy and raw material shortages, and transportation bottlenecks. Total factor productivity growth actually was negative for the second half of the 1970s as GNP growth for the Soviet Union declined from an average annual rate of growth of 3 percent for the first half of the decade to 2.3 percent for the second half. GNP growth averaged slightly under 2 percent per year for the first half of the 1980s.

GNP growth was actually greater than 4 percent per year during Gorbachev's first full year, attributable to a strong showing in agriculture and a reduction in the loss of worktime. Such enhancements in labor discipline typically result in one-time improvements that are difficult to sustain. Indeed, industrial performance was disappointing in 1987, and by midyear Soviet industry had experienced an annual growth

of less than 2 percent. For the remainder of this decade, GNP growth of around 2 percent has been predicted.²

The discussion below provides some additional information on Soviet growth prospects through the first decade of the twenty-first century. One of the difficulties faced by the Soviets has been the need to shift the economy from extensive to intensive growth. Extensive growth results from simple additions of labor and capital inputs. Intensive growth occurs when the inputs are used more effectively as a result of technical progress. The reduction in overall growth performance can be traced to declines in extensive growth that have not been compensated for with increases in intensive growth.

Extensive growth has declined as the combined growth of labor and effective capital have gotten smaller. The growth of the latter production input has been constrained by the slowdown in investment growth and the shortages and bottlenecks mentioned above.

At the same time, the failure to adequately modernize the nation's capital stock has caused intensive growth to be negligible. General Secretary Gorbachev has initiated a modernization program that will attempt to come to grips with the intensive growth issue. The core of this program is oriented toward the enhancement of Soviet manufacturing technology by developing the economy's technological base in such areas as electronics, machine tools, and computers.

To achieve this modernization, investment in the civilian machine-building ministries is to increase by 80 percent during the 1986-90 Twelfth Five Year Plan over that achieved in 1981-85. The annual production of computer equipment is to rise by 18 percent during the Twelfth Five Year Plan. Instrumentation equipment is to grow at an 11 percent annual rate, and numerically controlled machine tools are expected to grow at a 13 percent annual rate.

Many discussions of the relation between the Soviet military and civilian sectors emphasize the direct production competition between conventional weapons and civilian products. Although these types of investment goods may directly compete with the production of naval surface ships, submarines, and artillery, the Soviets have devoted a disproportionate share of their high-technology resources to the development and production of strategic weapons. This has been one factor thwarting Soviet efforts to

²Soviet economic performance through 1987 and the prediction of economic performance for the rest of the 1980s are discussed in *Gorbachev's Economic Program: Problems Emerge*.

improve their intensive growth. Therefore, there may be considerable direct competition between the modernization program and a near-term high-technology defense effort.³

The modernization program on long-run military activities will be affected by the direction taken. Clearly, by advancing the technological base of the economy, the Soviets will be better able to produce their traditional low technology weapons more efficiently. But there is also the issue of whether this program will permit them to better produce the high technology weapons that constitute, in the Soviet viewpoint, the emergent "scientific-technical revolution in military affairs."

It is important to appreciate the nature of the technologies required to achieve success in an SDI program. As Stephen Meyer has indicated⁴

Most of the public discussion in the West about these "Star Wars" weapons has focused on the kill mechanisms—lasers, particle beams, and homing projectiles—when, in fact, the keys to the success or failure of SDI are the technologies of target acquisition, tracking and pointing, and command and control. Sensors, computers, and highly-engineered electro-mechanical subsystems—products of electronics and miniaturization—are the linchpin of SDI.

To produce the highly engineered electromechanical subsystems requires substantial enhancements in Soviet manufacturing technology, and there have been many reports of U.S. superiority in this area. For example, recent joint testimony by CIA and DIA indicate the following U.S. lead in technologies that bear on manufacturing: microprocessors, 8–9 years; computer-operated machine tools, 8–12 years;

³The investment plan information is presented in *Gorbachev's Modernization Program*, p. 22. The relationship between defense and civilian industries is discussed in Statement of Henry Rowen, in *Allocation of Resources in the Soviet Union and China—1981*, hearings before the Subcommittee on International Trade, Finance, and Security Economics of the Joint Economic Committee, Congress of the United States, Part 7, October 15, 1981, 1982, p. 213. Stanley Cohn has argued that the Soviet defense sector has traditionally acquired a significant share of the output of the high technology sectors. For example, his analysis of the input-output table for 1972 indicates that the three machinery sectors that might be classified as being at the high end of technology—precision instruments, transportation equipment, and electronics sectors—delivered 44, 46, and 77 percent of their respective final demands to users other than consumption, investment, and net exports. The implication is that the final demands are delivered primarily to the defense sector. He discusses this in "Economic Burden of Soviet Defense Expenditures: Constraints on Productivity," *Studies in Comparative Communism*, Vol. XX, No. 2, Summer 1987, pp. 145–161.

⁴*Soviet Strategic Programs and the US SDI*, p. 276.

minicomputers, 8–10 years; mainframes, 8–12 years; software, 8–12 years; and flexible manufacturing systems, 8–10 years.⁵

The view that developments in the area of manufacturing technology are needed has been supported within the Soviet defense establishment. For example, Major-General M. Iasiukov has stated⁶

Today what is required for serial production of contemporary weapons and the newest combat equipment is not usual or ordinary equipment but the most modern and frequently unique equipment—new in principal instruments, numerically controlled machine tools, robot equipment, latest generation computers, and flexible manufacturing systems.

The requirement for “unique equipment” suggests that there may be advantages associated with emphasizing the specific tasks of these modern manufacturing production technologies. Although such a specialized approach is consistent with Soviet traditions, such a task-oriented approach may result in only limited spinoffs from one sector to another.

The specialized approach might be contrasted with one in which the Soviets first choose to build up the basic industrial base in such areas as microelectronics by developing dual-use technologies. But a disadvantage of dual-use technologies is that their potential effectiveness is lower than the more specialized approaches may achieve. To understand which approach is being taken, it is necessary to analyze the structure of the modernization program in detail.

PREDICTING SOVIET ECONOMIC PERFORMANCE

It will be useful to forecast a range of Soviet economic performance outcomes over the 1990–2010 time period. In an aggregate model of the Soviet economy, GNP is produced with the economy’s labor and capital and then distributed to consumption,

⁵Gorbachev’s *Modernization Program*, p. 5.

⁶Major General M. Iasiukov, “Voennaia Politika KPSS: Sushchnost’, Soderzhanie,” *Kommunist vooruzhennykh sil*, October 1985, p. 20, quoted in Abraham S. Becker, *Gorbachev’s Program for Economic Modernization and Reform: Some Important Political-Military Implications*, The RAND Corporation, P-7384, September 1987, p. 9. For a discussion of the Soviet General Staff’s concern about the revolution in military affairs, see Jeremy R. Azrael, *The Soviet Civilian Leadership and the Military High Command, 1976–1986*, The RAND Corporation, R-3521-AF, June 1987.

investment, defense, and other activities. The investment goods produced are used to augment the remaining capital stock.⁷

Two situations are examined: one in which annual investment growth equals 4 percent per year over the entire period, the other in which annual percent capita consumption growth equals 1 percent over the forecast period. In both of these cases, defense spending growth is assumed to be 2 percent per year.

An investment growth rate of 4 percent is about 1 percentage point lower than that specified in the Twelfth Five Year Plan. However, it has been argued that the investment plan may not be consistent with other plan objectives. Therefore, a 4 percent annual investment growth rate is probably a reasonable value to use for a sustained modernization program over the forecast period.

A 1 percent per capita consumption scenario is a plausible alternative in light of the argument frequently made that such an annual growth rate will insure that all major groups in Soviet society enjoy per capita consumption growth.

The annual defense spending growth rate of 2 percent is roughly comparable to Soviet experience since the mid-1970s. It may also be about equal to the growth rate that would support a fairly stable force structure with routine modernization at the historical readiness and sustainability levels.⁸

In making economic forecasts, one must specify or somehow determine the growth of total factor productivity (TFP), which equals the difference between the growth of GNP and that of the combined inputs of labor and capital. Recent historical experience suggests zero and possibly negative growth in TFP. Zero TFP growth means that GNP has grown no faster than the combined inputs of labor and capital and technical

⁷ Additional information on this aggregate model is provided in the appendix.

⁸ Robert Leggett has discussed the issue of investment plan feasibility in "Soviet Investment Policy: The Key to Gorbachev's Program for Revitalizing the Soviet Economy," in *Gorbachev's Economic Plans*, Volume 1, study papers submitted to the Joint Economic Committee, Congress of the United States, November 23, 1987, pp. 236-256. He also argues that the investment plan is not properly balanced because the investment to those sectors supporting the production of producer durables may not be adequate to support the overall target. With respect to per capita consumption growth, Mark Hopkins and Michael Kennedy have made the minimum growth level argument in *The Tradeoff Between Consumption and Military Expenditures for the Soviet Union During the 1980s*, The RAND Corporation, R-2927-NA, November 1982.

progress and has not succeeded in boosting the Soviet aggregate production process to a higher level.⁹

The Soviets have indicated that they hope to achieve annual growth rates of over 5 percent during the 1990s. This annual growth rate would be comparable to the one that they obtained from 1960–73, the high growth period after the end of World War II reconstruction. During this period, the average annual growth in TFP was 1.5 percent.¹⁰

To address the feasibility of the Soviets' objectives, it must first be assumed that the Soviets are able to maintain capital productivity during the 1990–2010 time period at the level achieved in 1990. Although constant capital productivity has been one of the characteristics of economic growth in Western economies, the Soviets have experienced considerable decreases in capital productivity since 1970.¹¹

Figure 1 displays the growth rate of GNP and the growth of TFP for this constant capital productivity scenario. We see that GNP growth never reaches the 5 percent goal and the growth of TFP requirement to sustain constant capital productivity remains above 2 percent. This is a rate greater than that achieved from 1960–73.

Although the possibility that the Soviets might achieve such performance can't be ruled out, this optimistic scenario might itself be undermined by a high-technology defense effort. Furthermore, very large increases in economic capacity permit all final demand claimants to share in the growth increment, and difficult tradeoff choices may not emerge. It is more interesting, therefore, to investigate plausible limits on TFP growth within which tradeoff decisions must be considered very carefully.

In one TFP growth scenario, historical trends continue and there is no growth in the productivity of the combined inputs. In this situation the Gorbachev program does not succeed. Although such an outcome may be too pessimistic if there is not a high-technology defense effort, the scenario will be useful in the discussion of an emulation

⁹With labor's share equal to 0.65 and capital's share equal to 0.35, I calculated that the average annual growth of TFP was -0.5 percent per year between 1970 and 1986. Using a somewhat lower share for labor (and higher share for capital), Laurie Kurtzweg obtains a lower growth in TFP over a similar period. See "Soviet Trends in Gross National Product," in *Gorbachev's Economic Plans*, pp. 126–165.

¹⁰Reported in Stanley Cohn, "Soviet Intensive Economic Development Strategy in Perspective," *Gorbachev's Economic Plans*, pp. 10–26.

¹¹I have calculated a fall in capital productivity from 0.45 to 0.21 between 1970 and 1986 when GNP is measured in 1970 rubles and the capital stock is measured in 1973 rubles. The fact that capital productivity has remained constant since 1950 is discussed in Paul Samuelson and William Nordhaus, *Economics*, Twelfth Edition, McGraw-Hill Book Co., New York, 1985, p. 795.

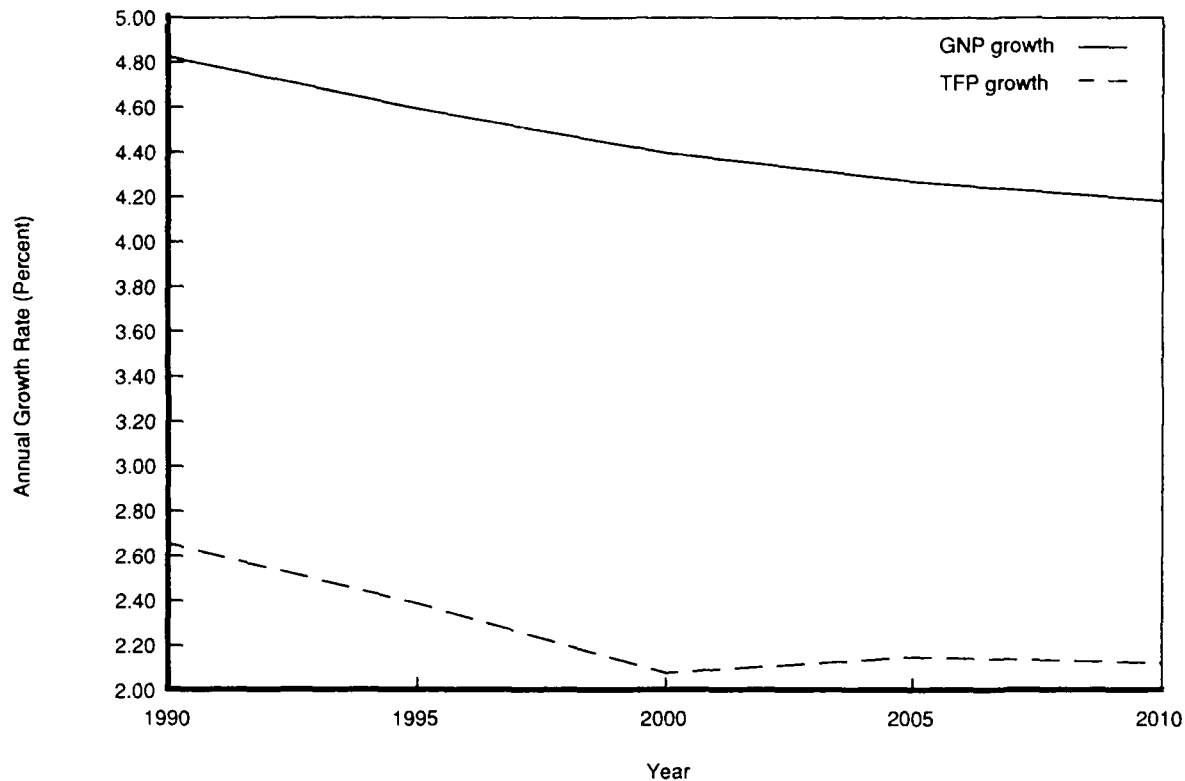


Fig. 1—Soviet GNP and TFP growth with constant capital productivity, 1990–2010

response, where the high-technology effort may compete with the modernization program and lead to an inability to achieve intensive growth. It is therefore a useful baseline from which to evaluate the effects of a Soviet high-technology SDI effort.

The second TFP scenario assumes that the Gorbachev modernization yields an annual growth in TFP of 0.5 percent. The Soviets would be disappointed in such an outcome, but this modest improvement in intensive growth performance could alleviate the difficult tradeoffs faced by the Soviets should the modernization program fail completely.¹²

Figure 2 provides an estimate of the growth of Soviet GNP under these two scenarios for the 1990–2010 time period. As expected, GNP growth is 0.5 percentage

¹²An 0.5 percent increase in TFP is roughly equivalent to an increase in the marginal productivity of capital of about 25 percent. I have also calculated that this was approximately the growth in TFP experienced by the U.K. during the 1980s. It is somewhat less, however, than the recent U.S. experience.

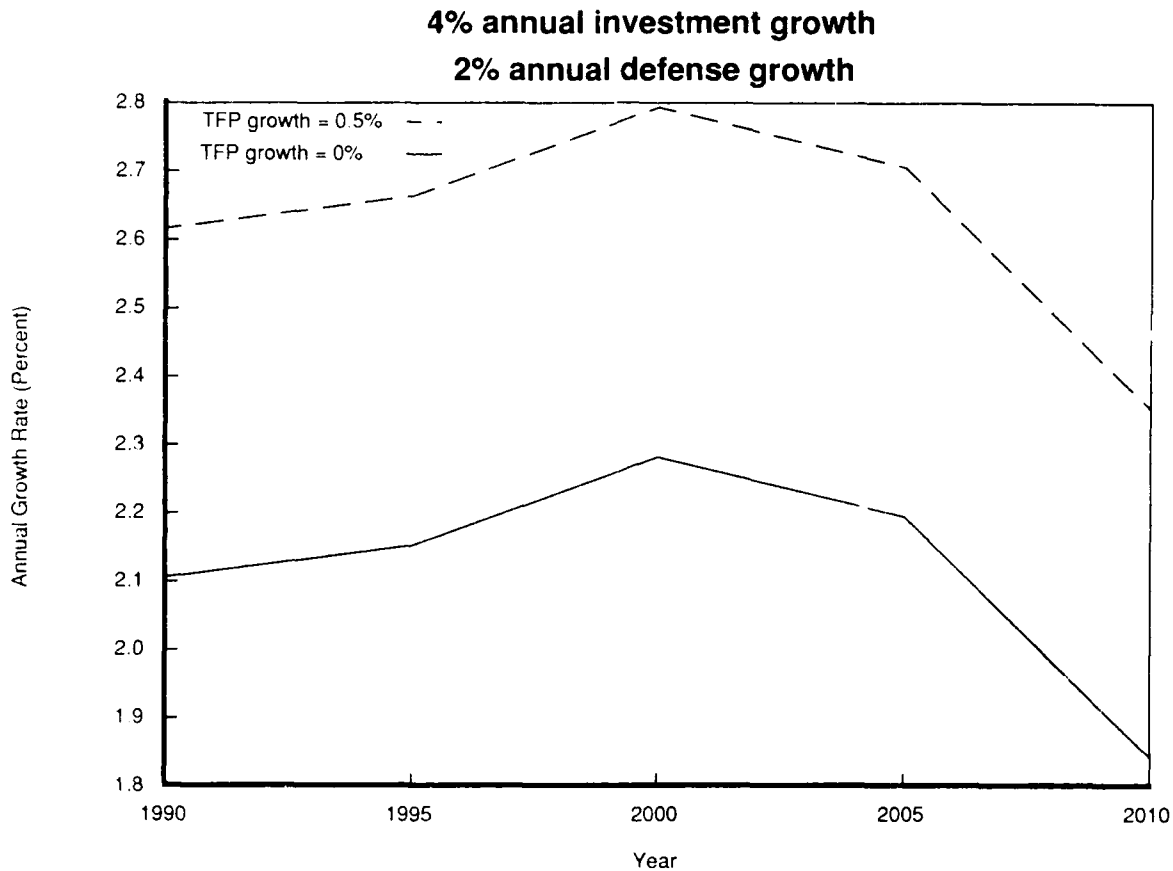


Fig. 2—Soviet GNP growth, 1990-2010

point lower when there is no growth in TFP. Under both scenarios, GNP growth first rises as the Soviets experience an increase in the growth of the labor force during the 1990s. This occurs even as the growth of the capital stock is declining.

In the first decade of the twenty-first century, GNP growth declines in both TFP growth situations as the Soviets experience a sharp decline in the growth of the labor force. Labor force growth during the decade declines from 1.2 to about 0.6 percent per year.¹³

¹³The labor force growth peaks around 2000, in part, because of the effect of low births during World II on reducing retirements around the turn of the century. The low increments to the work force between 2000 and 2010 are also affected by the decrease in Soviet fertility that occurred in the 1960s. Murray Feshbach and Ward Kingkade provided helpful comments on this issue.

To avoid such a decline in GNP growth, the Soviets would either have to increase TFP growth to offset the decline in the labor force growth or develop manufacturing techniques that permit them to substitute capital for labor more effectively than the historical trend. The modernization program itself is designed to achieve such increases in TFP growth, but such growth would have to increase between 2000 and 2010 to offset the decline in the growth of the work force. With respect to capital-labor substitution, developed economies have not yet learned how to achieve such across-the-board substitution enhancements, so it may be best not to assume that they are possible.

Figure 3 provides forecasts of per capita consumption growth for the two scenarios. The reason why such growth declines so dramatically from 2000 to 2010 is that, with GNP growth declining, the residual consumption growth must fall as investment and defense continue to grow at 4 and 2 percent per year respectively. Although it is not immediately apparent from the figure, the growth difference between the two scenarios increases over time, because the investment and defense shares of GNP

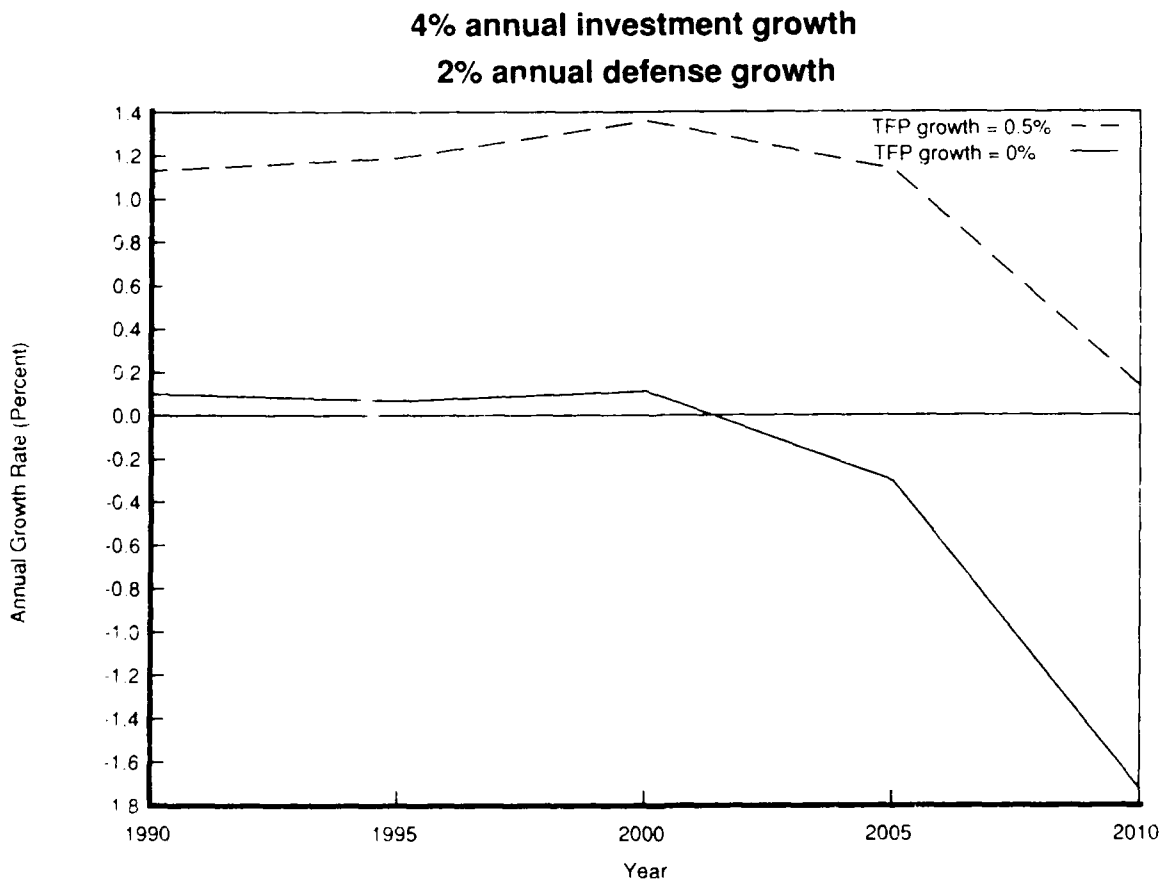


Fig. 3—Soviet per capita consumption growth, 1990-2010

will increase more in the no-TFP growth scenario than they will when annual TFP growth is 0.5 percent. Consumption's share and, in turn, growth rate will therefore decrease more when there is no growth in TFP.

When there is no growth in TFP, investment's share of GNP rises to over .47 in this fixed investment growth scenario. Because this end-use share is measured with a 1982 price base, and the Soviet efficiency in the production of investment goods might be expected to increase over time, the investment share of GNP in the current rubles of 2010 might be somewhat less. Nevertheless, it may be unreasonable to expect constant investment growth to be sustained if the modernization program fails. Therefore, an alternative scenario maintains per capita consumption at 1 percent per year over the planning horizon. Figure 4 contains the forecast of GNP growth for the two TFP scenarios.

If there is no growth in TFP, GNP growth will remain fairly flat during the 1990s. Fairly rapid deceleration will then occur the next decade as the growth of the labor force declines. Total factor productivity growth of 0.5 percent per year, however, will be

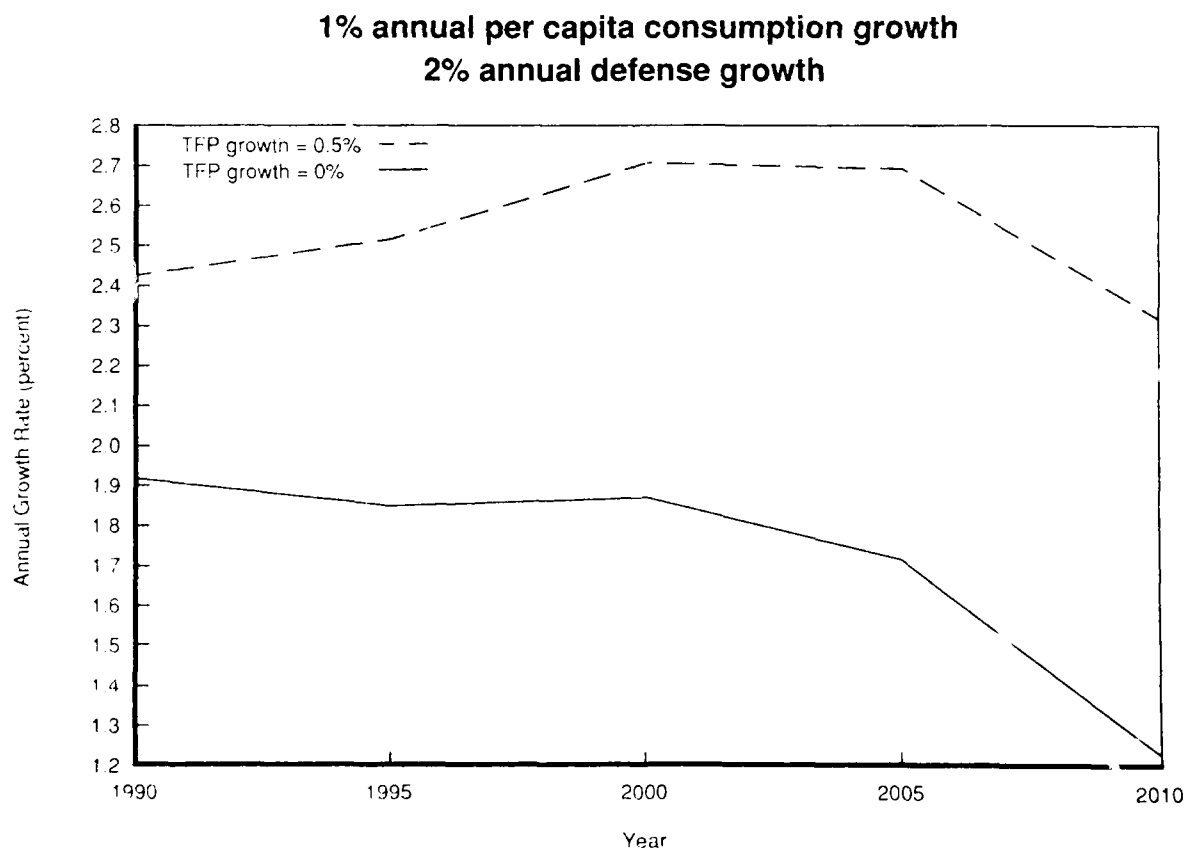


Fig. 4—Alternative Soviet GNP growth, 1990-2010

sufficient to keep GNP growth between about 2.4 and 2.7 percent per year, where the indicated rise and fall in growth is primarily affected by labor force demographics.

Without TFP growth the Soviet situation is somewhat precarious. Consider again Fig. 3. There is barely any growth in per capita consumption until 2000 in the no TFP growth case, at which time it turns negative. Higher defense spending growth rates might therefore lead to a near-term decline in per capita consumption.

Of course, if defense spending growth is reduced, per capita consumption growth can be enhanced somewhat. Figure 5 presents the tradeoff relationship between defense growth and per capita consumption growth for the two alternative growths in total factor productivity.

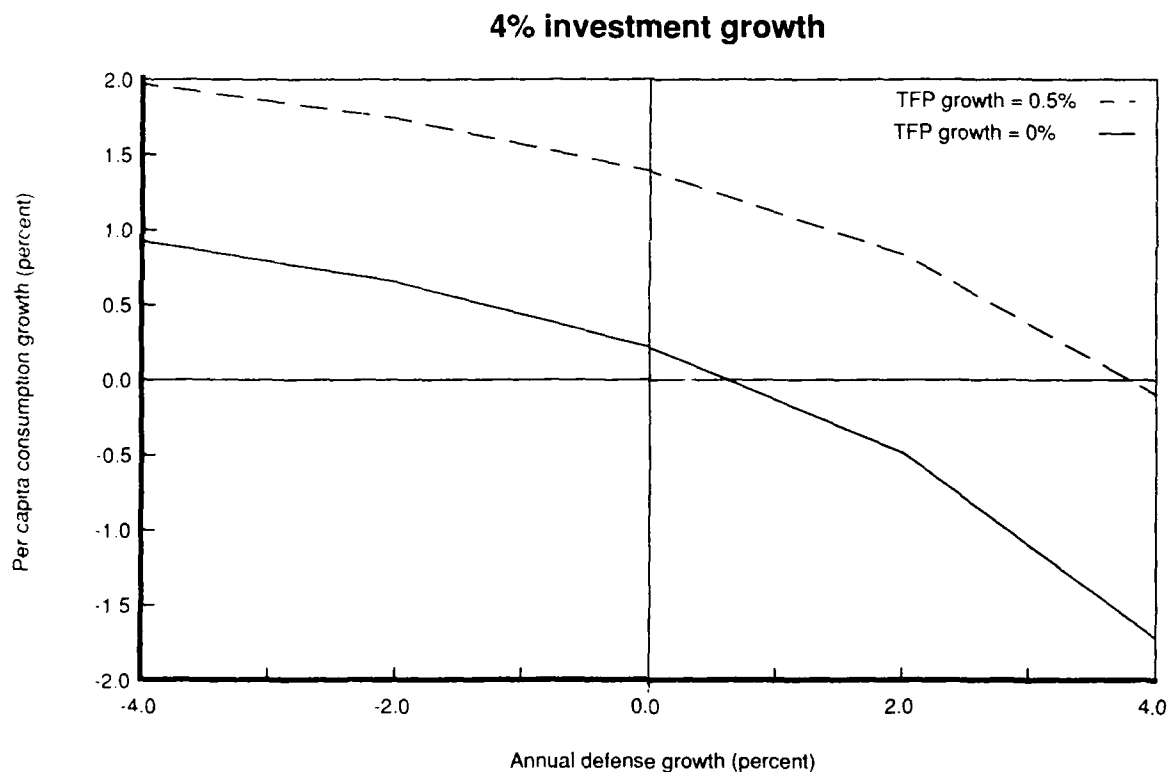


Fig. 5—Soviet growth alternatives, 1990-2010

III. COST METHODOLOGY

The opportunity costs of U.S. and Soviet defense activities differ substantially and provide evidence that the United States is more efficient than the Soviet Union in producing high-technology defense goods. This means that as the level of technology embodied in different defense goods increases at some time, a dollar's worth of defense goods tends to cost a greater amount of rubles in the Soviet Union.

Some sense of this effect can be obtained from Table 1, which presents ruble-to-dollar ratios in 1982 rubles and 1986 dollars for the major defense resource categories—RDT&E (research, development, testing, and evaluation); military investment, which consists of procurement of military equipment, and construction; and the operating

Table 1

RUBLE-DOLLAR RATIOS (1982 rubles-1986 dollars)

Defense	.38
RDT&E	.61
Investment	.51
Operating	.25
O&M	.45
Personnel	.11
Space	.61

SOURCES: Defense ruble-to-dollar ratios are estimated from data contained in D. Derke Swain, "The Soviet Military Sector: How Is It Defined and Measured," paper prepared for The Hoover/RAND Conference on the Defense Sector and the Soviet Economy, 23-24 March 1988; *Soviet and U.S. Defense Activities; and Allocation of Resources in the Soviet Union and China—1985*, hearing before the Subcommittee on Economic Resources, Competitiveness, and Security Economics of the Joint Economic Committee, Congress of the United States, Part 11, March 19, 1986, pp. 108-109. Small adjustments were made to the ruble estimates to obtain comparability with U.S. defense definitions. The ruble-to-dollar ratio for space activities in 1976 rubles and 1976 dollars is contained in I. Edwards, M. Hughes, and J. Noren, "U.S. and U.S.S.R.: Comparisons of GNP," in *Soviet Economy in a Time of Change*, a compendium of papers submitted to the Joint Economic Committee, Congress of the United States, Volume 1, October 10, 1979, Washington, D.C., 1979, p. 399. This ratio is converted to 1982 rubles with the CIA price deflator for defense procurement activities and to 1986 dollars with the BEA deflator for missiles.

category, which includes operations and maintenance (O&M) and military personnel. An estimate of the ruble-to-dollar ratio for Soviet space mission is also provided.

At the high-technology end of the spectrum are *space activities with a ruble-to-dollar ratio comparable to that of military RDT&E*. This suggests that although the Soviets have achieved a considerable space effort, it has been accomplished at very high opportunity cost.

Space and RDT&E are closely followed by military investment. The ruble-to-dollar ratios within the aggregate investment category would be expected to vary by mission. Because of the uncertainty associated with these individual ratios, however, the aggregate ruble-to-dollar ratio for military investment is used in this analysis.

Within the operating resource category, O&M has a ruble-to-dollar ratio of .45. To understand why this ratio is lower than RDT&E and military investment, one should recognize that the maintenance part of this resource category is likely to have a ratio similar to the military investment stocks that are being maintained. The operations part of O&M—purchases of petroleum and lubricants, utilities, transportation, and other general operating items—would, however, probably have a lower ruble-to-dollar ratio than RDT&E and military investment because of the Soviet comparative advantage in energy production. Therefore the overall ratio for O&M, which is a weighted average of the two underlying ratios, would be lower than the ratio for military investment and RDT&E.

Military personnel is the resource category with the lowest ruble-to-dollar ratio. This category includes pay and allowances, food, and personal equipment, and the low ruble-to-dollar ratio results, in part, from the low ruble cost of Soviet conscripts. However, the ratio for military personnel may vary by service as the officer/conscript ratio changes. A high-technology service such as the Strategic Rocket Forces should use relatively more officers and therefore more expensive personnel than the defense average.

IV. OFFSETTING RESPONSE

This section analyzes the burden of a Soviet offsetting response to the U.S. Strategic Defense Initiative. An analysis of marginal dollar cost exchange ratios undertaken at RAND by Timothy Webb permits conversion into rubles of the dollar costs of various offsetting Soviet responses to alternative U.S. SDI efforts. The conversions are made with the ruble-to-dollar ratios from Table 1.

Although several SDI architectures have been analyzed, and each of these is evaluated under a range of alternative assumptions, the base case of the RAND analysis is used to illustrate the computation of the offsetting costs. In the architecture selected, the space-based portion consists exclusively of rocket-propelled interceptors (RPIs). In simple terms, this is a system with deployed carrier satellites, each of which would contain several RPIs that could be used against Soviet ICBMs during the boost, post-boost, and mid-course phases of intercontinental flight. The specified system contains some ground-based terminal defense capability that permits a final strike against the attacking reentry vehicles. This latter feature is called a high-endoatmospheric defense system.

By specifying the parameters of the RPI system, one can estimate the relationship between the total procurement and launch cost and the number of RPIs in orbit. For the purposes of this discussion, the key characteristics of the particular RPI system analyzed are that one RPI shot is taken at a Soviet ICBM during each of the boost, post-boost, and mid-course phases of the flight, and that each RPI fired has a single shot kill probability of 0.8. It is also assumed that this all-RPI system has perfect decoy discrimination during mid-course of the attack flight. A 90 percent production learning curve is applicable to estimating the system cost, and the components in space are assumed to have a 15 year on orbit life without replacement. Given these and other parameter values, the relationship between the number of rocket-propelled interceptors in orbit and dollar procurement and launch costs is presented in Fig. 6.¹

¹The analysis of the offsetting response presented is based on personal communication from Timothy Webb of RAND. Other cases that he has analyzed include the effect of decoys assuming no RPI shots in mid-course, 90 percent learning during production, and 50 percent replacement of space-based components during a 15 year period. He also analyzes an architecture in which a space-based laser system employed during the boost

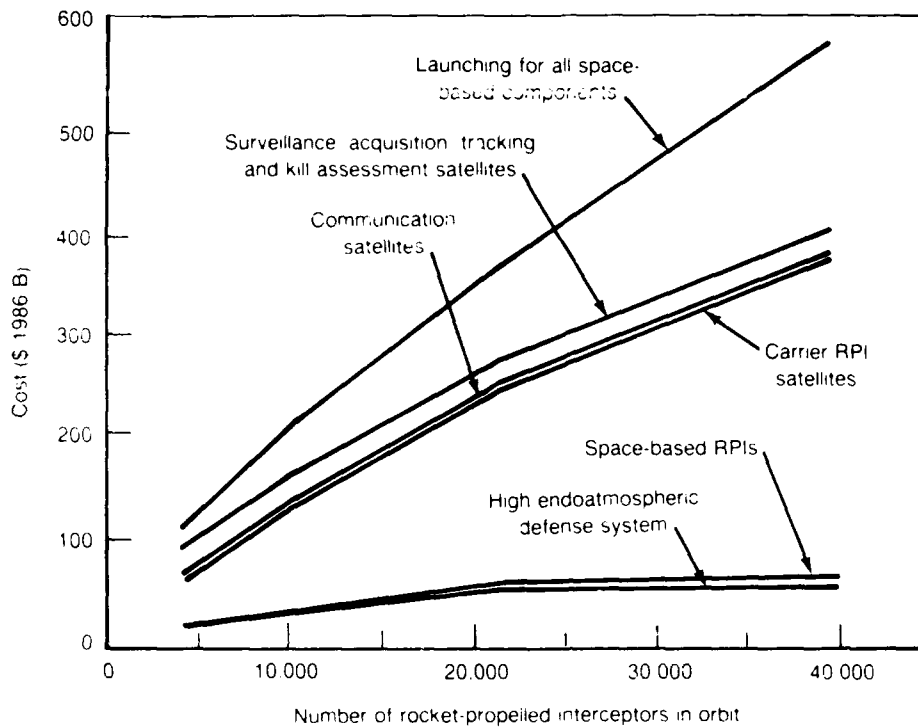


Fig. 6—U.S. defense cost vs number of RPI in orbit

As shown in the figure, as one varies the number of RPIs in orbit from 4,000 to 40,000, the procurement and launch costs increase from over \$100 billion to almost \$600 billion. Most of these costs result from the launch costs of all space-based components and the cost of the carrier satellites. The costs of the deployed RPIs and the communication, surveillance, acquisition, tracking and kill assessment satellites are not a significant proportion of total costs. Also, it is assumed that some increases in the cost of the ground-based terminal defense capability occurs as one increases the number of RPIs.²

To translate alternative levels of strategic defense capability into military effectiveness, it is necessary to incorporate the RPI levels into a military-strategic

phase is combined with the RPI system. Based on Webb's calculations, this U.S. architecture becomes economical only at very high effectiveness levels.

²RDT&E and military construction costs are excluded from these estimates. These can be viewed as fixed costs of the SDI system and the analysis, therefore, focuses on the variable cost component.

capability model that permits different attack sizes for Soviet ballistic missile forces. The model is the one developed at RAND plus a diagram that relates alternative values of both U.S. dollar costs and Soviet RV attack size to the fraction of the U.S. target value attacked that survives. Figure 7 displays this information for a range of U.S. expenditure levels and Soviet attack sizes.

The remainder of this discussion focuses on the case in which U.S. procurement costs are about \$500 billion (curve F of Fig. 7) over the 1990–2010 time frame. Note that this results from the satellite deployment of about 34,000 RPIs. As the Soviets increase the number of reentry vehicles (warheads) from 4,000 to almost 10,000, about 98 percent of the target value attacked survives. The percent surviving then declines until an attack size of 24,000 reentry vehicles (warheads) leaves about 60 percent of the target value surviving.

Although further analysis is required to determine whether the Soviets would be satisfied with such a result, the Soviet perception of this situation would also be shaped by their concern that a U.S. first strike reducing Soviet RVs to under 10,000 would leave the Soviets themselves with limited second-strike retaliatory capability. At least 98

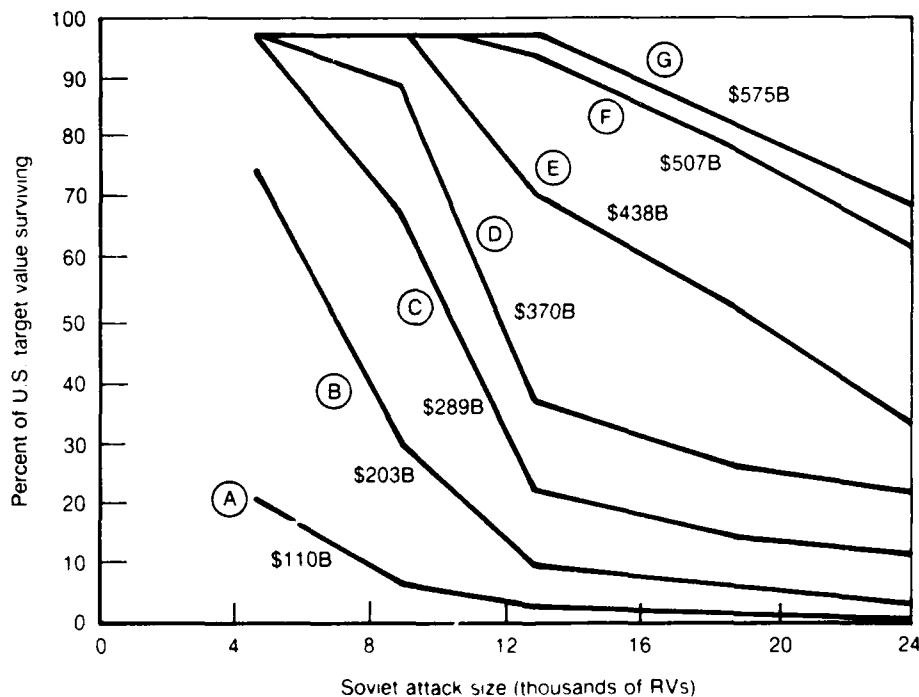


Fig. 7—Rocket-propelled interceptor defense effectiveness for various U.S. SDI cost and deployment assumptions

percent of the U.S. target value attacked would survive a Soviet attack of no more than 10,000 RVs.

The RAND estimate of the dollar cost of the various attack sizes that was obtained from the historical trend of U.S. guided missile costs was used to translate the alternative Soviet attack sizes into ruble costs. Soviet attack costs are assumed to exclude procurement of missiles already deployed by 1985 (sunk costs) but include all modification costs, costs of new missiles, and 15 years of operations and support (O&S) costs for all missiles.

Figure 8 contains the estimated dollar cost relationship. If one ignores sunk costs, the cost to the Soviets in 1986 dollars of a 4,000 RV attack is less than \$10 billion. The cost of a 24,000 RV attack increases to about \$90 billion.³

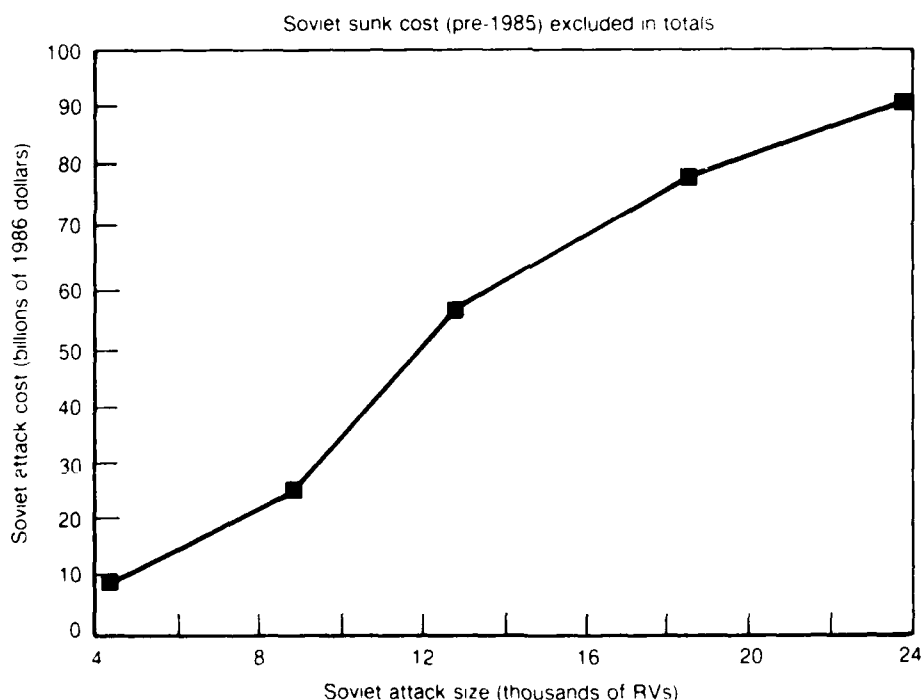


Fig. 8—Soviet attack cost vs attack size

³A 4,000 RV attack would permit the Soviets to hold in reserve a substantial proportion of their existing inventory. One may question whether it is possible to allocate part of the incremental cost of the total Soviet RV force to that part used during a first strike. However, as the Soviet attack size increases beyond the approximately

Although dollar costs provide useful information about the *size* of Soviet defense activity, they do not provide information about the domestic *burden* to the Soviets of a defense effort. The domestic cost to the Soviets is estimated by applying ruble-to-dollar ratios to estimates of the separate procurement and O&S costs. Figure 9 contains the resulting relationship between the fraction of the target value attacked that survives and the cost to the Soviets during the 1990–2010 time period measured in 1982 rubles.⁴

For comparison with the case in which the U.S. deploys a \$500 billion SDI system, the ruble cost of offsetting a \$200 billion U.S. system is also shown.

By spending about 45 billion rubles between 1990 and 2010, (or about 2.25 billion rubles per year) to fund an attack size of 24,000 RVs, the Soviets can partially offset an SDI effort that results in approximately 34,000 RPIs and costs about \$500 billion. As shown in Fig. 9, the fraction of target value attacked that survives a Soviet first strike with this combination of Soviet offensive and U.S. defensive forces is reduced to about 60 percent.

If the U.S. spends \$200 billion to acquire almost 10,000 RPIs, the Soviets can offset this system more effectively with 24,000 RVs so that less than 5 percent of the U.S. target value can be expected to survive.

There is uncertainty as to the precise value of the ruble-to-dollar ratios employed. Suppose that a realistic upper range is twice as high as estimated. Then, the cost to the Soviets of 24,000 RVs would be 90 billion rubles, or about 4.5 billion rubles per year over the 20 year period. It might also be appropriate to assume that the ruble-to-dollar ratios are unlikely to be smaller than one-half those identified in Table 1. This would result in an expenditure of 22.5 billion rubles or a little over 1.1 billion rubles per year. Therefore, a reasonable range of costs to the Soviets that would have to be incurred to reduce the surviving target value to about 60 percent of the original value when the U.S. deploys a \$500 billion SDI system would be from about 1 to 4.5 billion rubles per year.

10,000 RVs the Soviets hold in inventory, it may be reasonable to assume that only a modest proportion of Soviet RVs are held in reserve. Then, with the allocation of cost between those RVs used and those RVs held in reserve not being an issue, the attack costs presented in Fig. 8 would unambiguously portray incremental costs.

⁴For procurement and maintenance expenditures, I use a ruble-to-dollar ratio of 0.61. This ratio is somewhat higher than for all military investment, which includes military construction. For personnel, I use the ruble-to-dollar ratio of 0.11 from Table 1. To obtain the ruble estimates for the 1990–2010 time period, I have also eliminated those parts of the maintenance and personnel costs included in Fig. 8 that would be incurred after 2010.

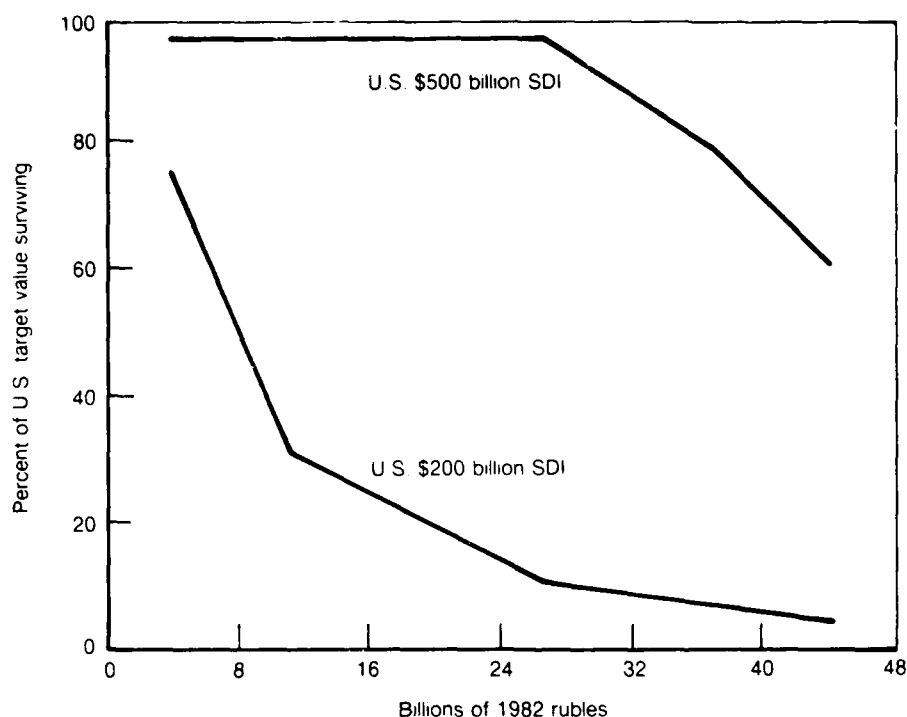


Fig. 9—Cost of Soviet offsetting response to SDI, 1990-2010

As Soviet defense spending was about 108 billion rubles in 1985, either end of the range constitutes a fairly small percent of annual defense spending.

For such a moderately small percentage change, it would probably not be possible to identify specific defense or nondefense areas where offsetting cuts would be made. In the defense area, the reallocations would take the form of stretchouts or reductions in many other strategic and conventional programs. Perhaps consumption or civilian investment would be reduced at the margin. Clearly, such an incremental charge could be absorbed in ways too numerous to specify.⁵

One should be very cautious when interpreting the above analysis. To fully evaluate the effect of a Soviet offsetting response on the strategic balance requires a careful analysis of the effect of the prospective outcome on U.S. and Soviet deterrence.

⁵The Soviet defense total is contained in "The Soviet Military Sector: How It Is Defined," p. 12a. Note, however, that if one changed the ruble-dollar ratios one would also change total defense spending.

Indeed, the Soviets may perceive that it is necessary to produce an essentially unlimited number of reentry vehicles in order to *maintain* current objectives in light of a U.S. SDI program. But they would also be sensitive to the fact that the United States may, in turn, be able to counter such unlimited proliferation through its own increase in reentry vehicles.

Furthermore, it might be argued that U.S. extended deterrence capabilities would be greatly enhanced by the \$500 billion program if a Soviet second strike can destroy only a low fraction of the U.S. target value. However, it might be possible to spend the \$500 billion in other ways to achieve an even greater effect on deterrence.

V. EMULATION RESPONSE

This section evaluates the economic burden of a Soviet SDI system that is deployed in response to the U.S. effort. To analyze the economic implications of such a response, the point of departure is a U.S. SDI effort of \$500 billion in 1986 dollars. If this total is converted to 1982 rubles using a ruble-to-dollar ratio for space activities of 0.6, which approximates the ratio indicated in Table 1, one can obtain an estimated domestic cost to the Soviets of 300 billion rubles. If the Soviets are only half as efficient in their SDI related space activities as they have been estimated to be in their historical space activities, their cost would be 600 billion rubles.¹

Estimating the effect of a Soviet SDI emulation response on economic performance requires consideration of several issues. First of all, as indicated above, modernization may, in fact, be a precondition for an emulation response. If so, the Soviets will be unable to respond to the United States until they have further developed their military-industrial base.

It is also possible that even without emulation the Soviet modernization program will not be successful. The front end of the program is so heavily weighted toward quantity targets that the quality objectives may be impeded. With an emulation response, modernization will be all the more difficult given the scarce high-technology resources.

In light of these considerations, it is reasonable to assume that Soviet historical economic trends continue to apply over the next 20 years and that there will be zero growth in TFP. Even if the Soviets were to decide that the modernization program was not a precondition for an emulation response, they would be concerned that such a response would absorb such a large portion of the economy's scarce high-technology resources as to undercut the Gorbachev modernization program. In their calculations, therefore, attention would be drawn to a scenario in which emulation and modernization are competitive.

For comparison, however, is an analysis of a Soviet emulation response for the situation in which the growth of TFP equals 0.5 percent per year. The modernization

¹In view of the Soviet lag in microprocessors and the other technologies discussed above, an emulation response would be expected to cost more than \$300 billion rubles if the Soviet SDI effort requires greater use of these technologies than have their space activities.

program increases economic capacity somewhat at the same time as emulation occurs. How much does this type of productivity growth ease the admission of an SDI program into the economy?

Several assumptions are made: There is no Soviet SDI program, and the estimated defense spending growth rate is 2 percent per year—the approximate defense spending growth rate since the mid-seventies. Furthermore, the Soviet SDI effort is not absorbed within this 2 percent defense spending baseline. Rather, it results in an increment to the baseline defense spending path. This defense spending increment at first occurs at the expense of consumer goods and services. Then, the Soviet SDI program is assumed to lead to a reduction in civilian investment and in turn GNP.

Figure 10 portrays the three defense spending patterns—no Soviet SDI, a 300 billion ruble program, and a 600 billion ruble program. For the Soviet SDI effort, the buildup and decline in cost represent a hypothetical, though plausible, expenditure pattern.

First, investment growth is maintained at 4 percent each year during the evaluation period. As indicated above in Sec. II, this captures the spirit of the current modernization program, which is to emphasize capital formation with modernized equipment.

With investment specified, capital formation remains unchanged under the different defense spending scenarios. The trend for GNP, therefore, does not vary with the size of the Soviet program. It is, however, affected by the assumptions made concerning the growth of TFP. In Fig. 2 above we provided estimates of the *growth* of GNP from 1990–2010. Figure 11 presents these same predictions in terms of the *level* of GNP for the two productivity assumptions.

The two productivity cases are examined separately. In the base case the historical trends continue, and there is no growth in TFP. A 300 billion ruble Soviet SDI program from 1990 to 2010 corresponds to an average of about 1.5 percent of GNP each year. With the investment trend specified, the resulting GNP trend is invariant with respect to changes in Soviet defense activity. Therefore, consumption, the only other major end user of national output, would be affected. Figure 12 summarizes the per capita consumption trend under the alternative defense spending assumptions.

From the Soviet standpoint, the situation is unpleasant even if there is no SDI effort. Per capita consumption remains fairly flat until 2000 and then begins to decline as employment growth slows during the first decade of the twenty-first century.

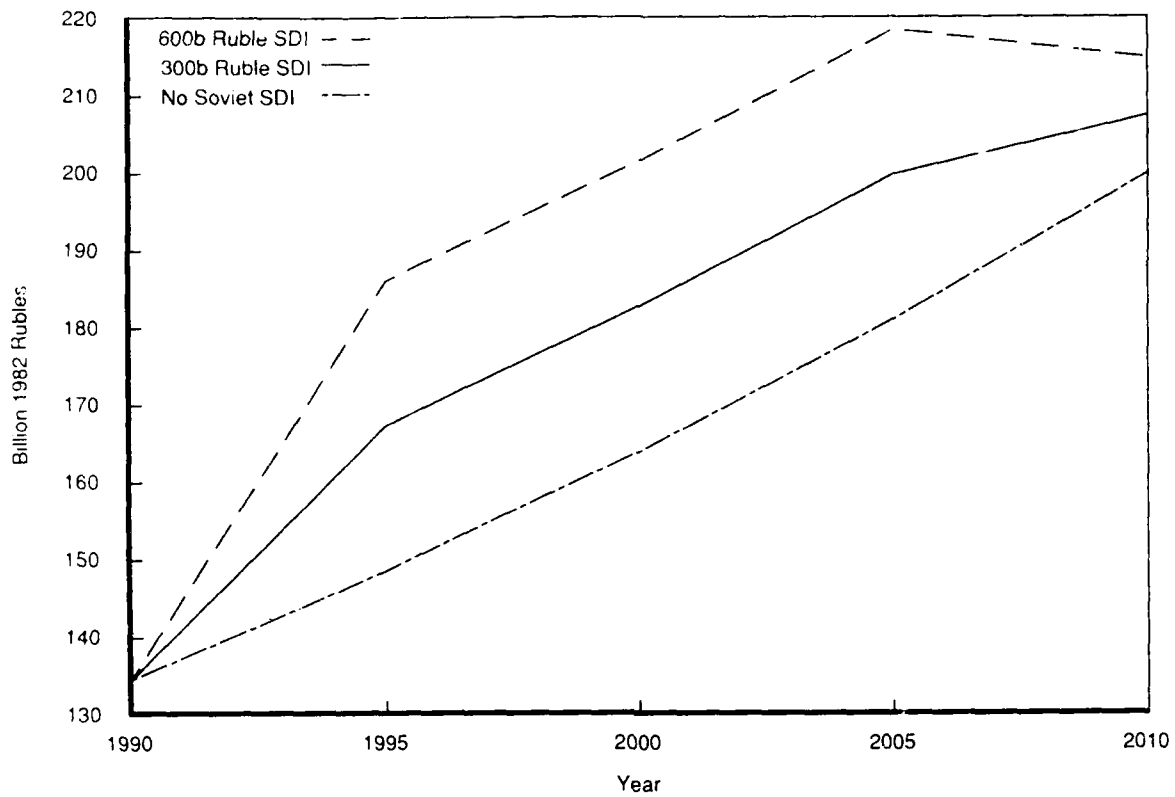


Fig. 10—Alternative Soviet defense spending patterns

4% annual investment growth
2% annual defense growth

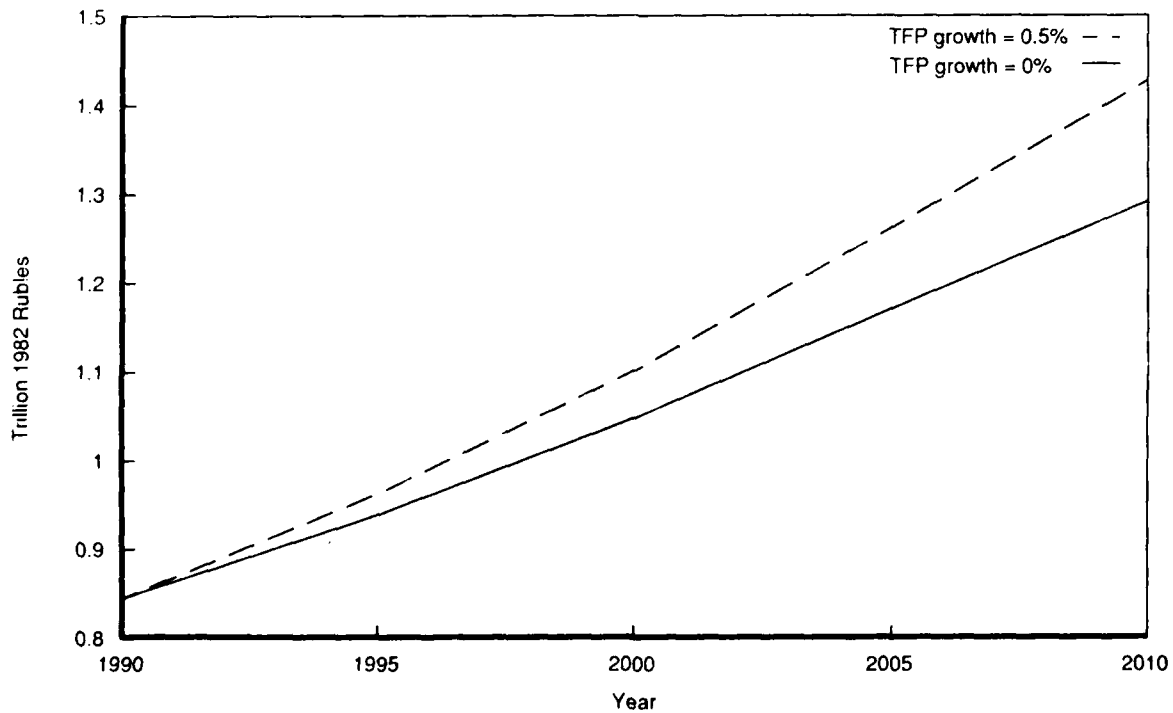


Fig. 11—Soviet GNP, 1990-2010

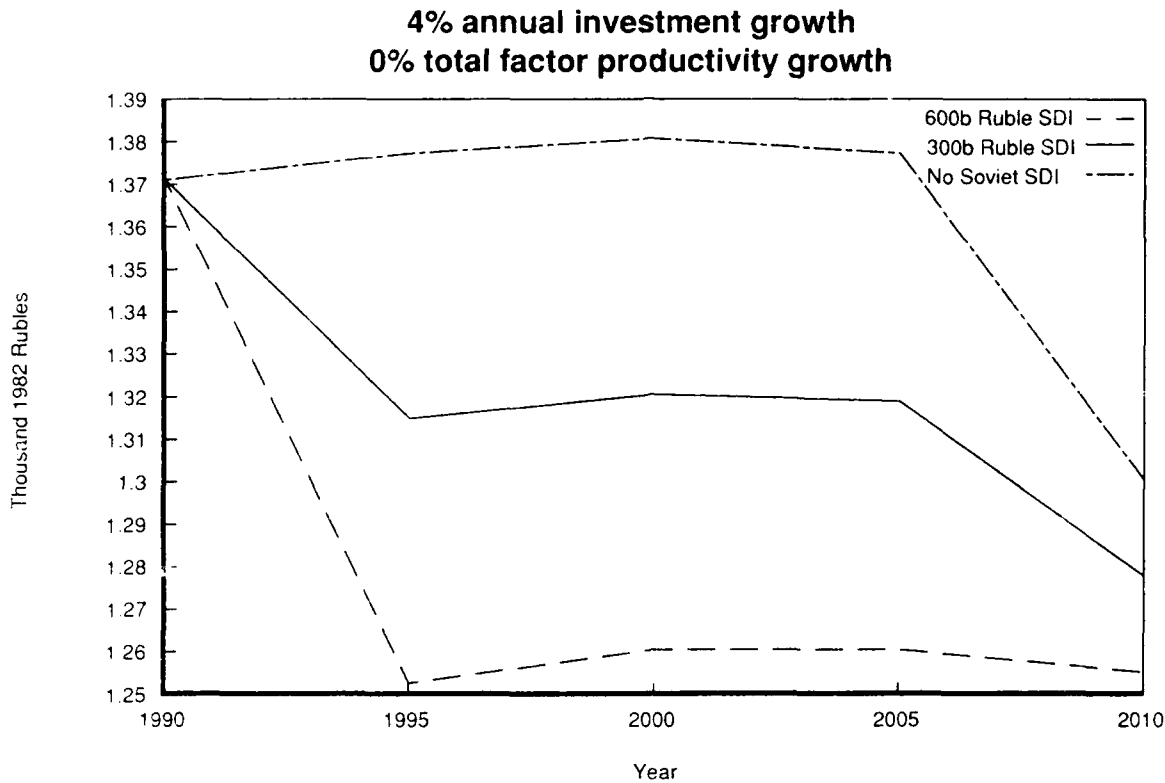


Fig. 12—Soviet per capita consumption, 1990-2010

With an SDI effort that costs either 300 or 600 billion rubles, the per capita consumption decline begins with the initiation of the program. It would then remain fairly flat in either ruble spending situation. Then, as the 300 billion ruble SDI program is winding down, the decline in employment would induce a decline in per capita consumption after 2005. For the 600 billion ruble case, per capita consumption would remain fairly flat at its lower level.

The fall in per capita consumption that occurs when there is no Soviet SDI also suggests that it may be implausible to assume that investment growth continues at 4 percent when there is zero growth of TFP. As indicated above, the share of GNP allocated to investment increases to over 47 percent in 2010 even when the baseline defense spending pattern is maintained. Therefore, the situation in which per capita consumption growth is maintained at 1 percent per year is also analyzed.

In this economic scenario, the investment trend, and in turn the GNP trend, would vary with the alternative defense spending assumptions. The GNP trends obtained are displayed in Fig. 13.

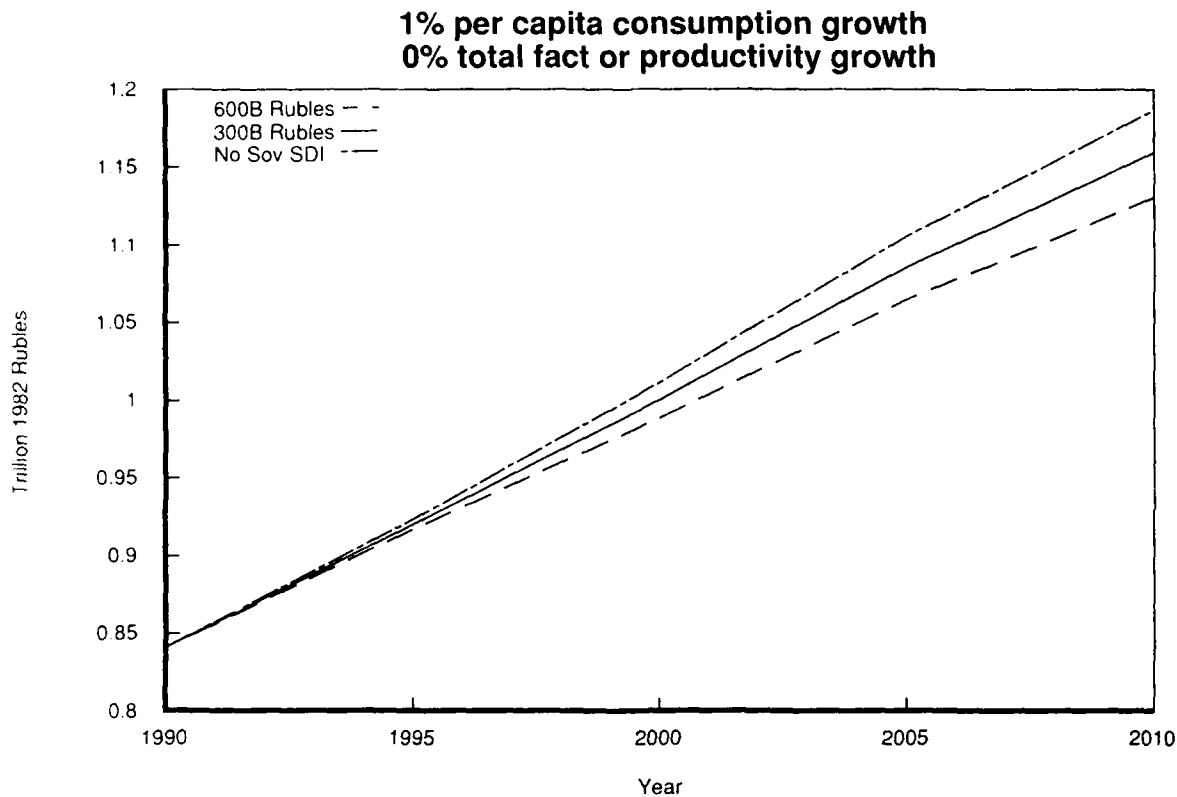


Fig. 13—Alternative Soviet GNP, 1990-2010

With per capita consumption growth now being maintained, investment would be reduced from the trend path as defense spending increases. The growth of GNP, therefore, would be affected. Figure 13 indicates there could be a decline in the growth performance of GNP as a result of the SDI effort.

Finally, the Soviet per capita consumption is presented when annual TFP growth is assumed to equal 0.5 percent. Figure 14 shows that investment growth can be maintained at 4 percent per year at the same time as per capita consumption continues to rise, when there is either no SDI or a 300 billion ruble program. Thus, moderate growth in total factor productivity generates sufficient extra capacity to prevent per capita consumption from declining. When the cost of the Soviet program is 600 billion rubles, however, there would still be some initial decline in per capita consumption until 1995.

A comparison of Figs. 12 and 14 indicates the importance of the TFP assumption. This key parameter is an important determinant of the Soviet per capita consumption trend and whether it will continue to rise or eventually fall during the forecast period.

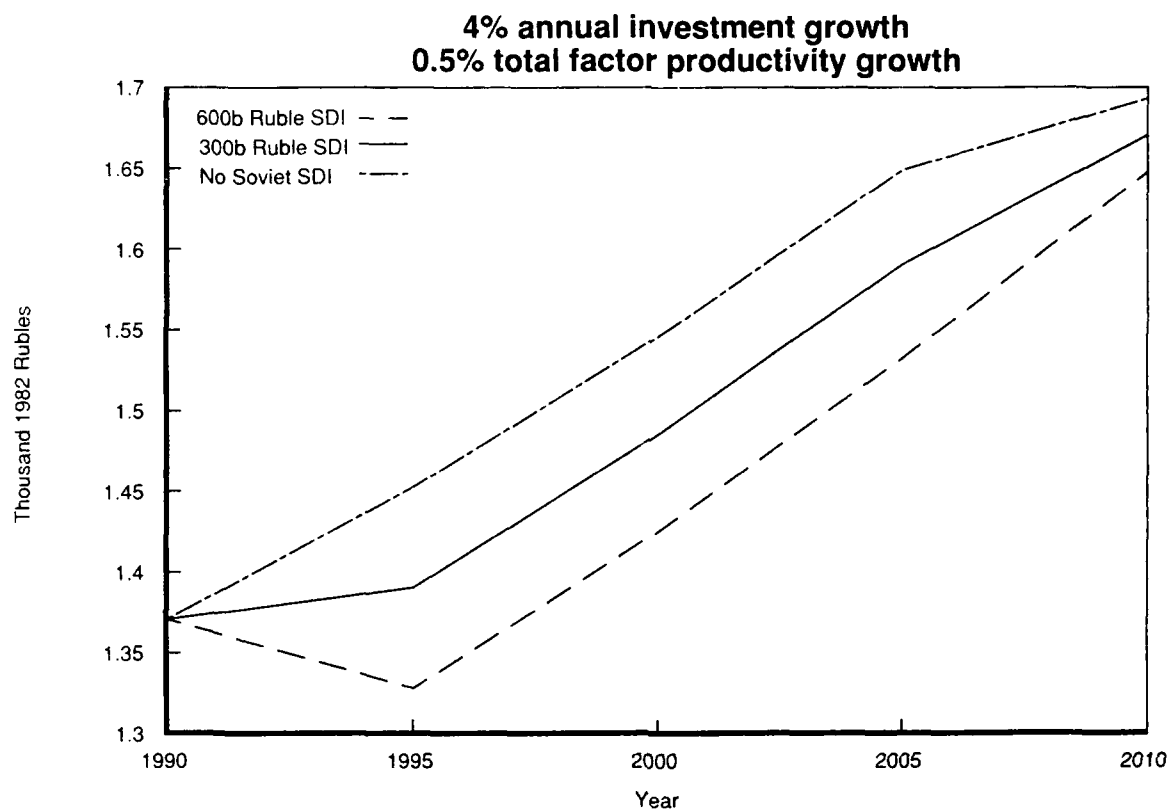


Fig. 14—Alternative Soviet per capita consumption, 1990-2010

VI. CONCLUSIONS

This analysis of the burden to the Soviets of a response to a U.S. SDI effort is set within the context of a deteriorating economic situation that is being challenged by General Secretary Gorbachev with an extensive modernization program. Although the extent to which this modernization program is a precondition for a Soviet SDI effort is unknown, there is at least some direct competition between this program and such a high-technology defense effort.

If the modernization program is unsuccessful, and the Soviets attempt to maintain rapid investment growth, they may begin to experience a decline in consumption even if the modest defense spending trends of the last decade continue and there is no great emulation response to the U.S. effort.

If, however, there is an emulation response, and if the modernization program is sustained but not successful in intensifying the Soviet economy, there may be a near-term decline in per capita consumption. Successful modernization, however, may provide the Soviets with a sufficient additional capacity to prevent the decline in per capita consumption. However, there is a large enough probability that modernization will compete with emulation that Soviet attention will be drawn to the zero TFP growth scenario.

Like ourselves, the Soviets do not have a clear understanding of the extent to which the Gorbachev modernization program would compete with, or possibly even be a precondition for, an emulation response. A large Soviet emulation program could so strain the technological resources of the Soviet Union as to undercut the entire modernization program. If this were to happen, the Soviets would be unlikely to break out of their extensive growth trap. Economic improvement depends on productivity improvements, and without high quality R&D and investment resources applied to the civilian sector, little will be forthcoming.

This analysis suggests that the Soviets can partially offset a U.S. SDI effort with a ruble expenditure that is a small percent of current defense spending. Although the Soviets may regard such a response as unsatisfactory for a variety of reasons, one needs to take account of the striking contrast with the burden of an emulation response. It seems reasonable to hypothesize, therefore, that the Soviets will choose not to directly

emulate the U.S. SDI activities, at least until they had an opportunity to modernize their technical-economic base. The next step is to determine whether this hypothesis is supported by detailed military-technological analysis.

APPENDIX

The aggregate model used in this analysis consists of a single technological relationship in which GNP is produced with inputs of labor, capital, and total factor productivity. The economy's final output is then distributed to consumption, defense, investment, and other final demands. The resulting investment is used to augment the undepreciated capital stock. Figure A.1 depicts such a model. For ease in illustration, the other final demands are ignored.

The link between population and labor force and also the rate of depreciation must be specified. The growth of total factor productivity is based on either historical experience or analytical judgment. A Cobb-Douglas production function is assumed applicable in this analysis with labor and capital elasticities of output equal to 0.65 and 0.35 respectively. The annual depreciation equals .035, which is consistent with

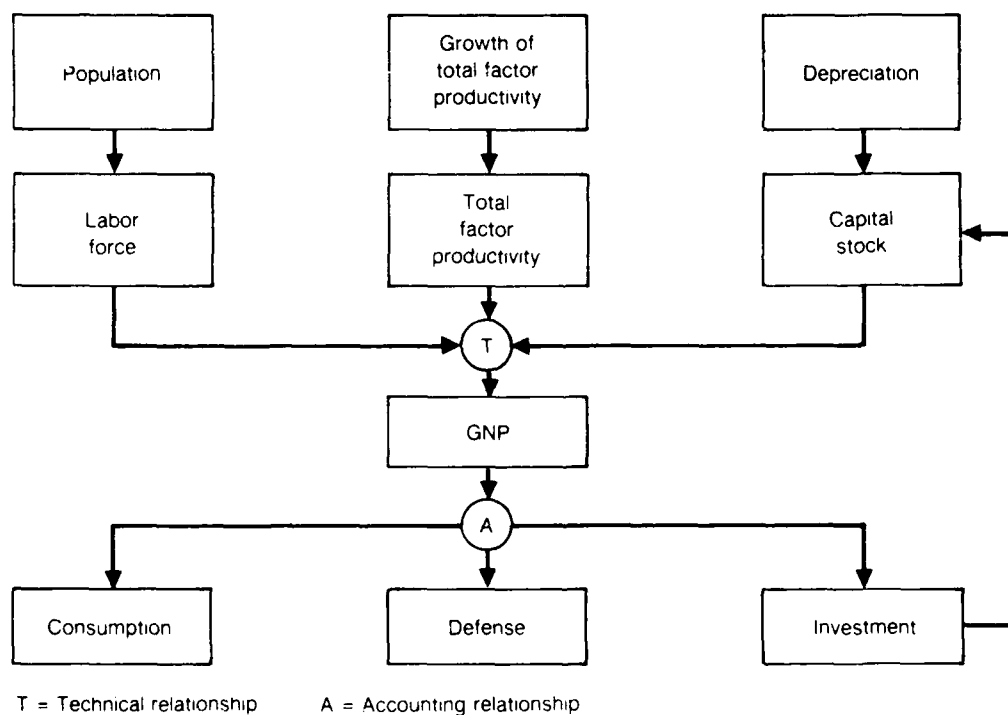


Fig. A.1—Soviet aggregate economic model

historical experience. This depreciation rate accounts for both capital repair and retirements.

This model used 1985 as the base year. The time trend for defense spending, and either investment or consumption, are specified, and the model is used to determine GNP.¹

This model assumes that consumption, investment, and defense can be exchanged for each other ruble-for-ruble in any period, and in many situations this is a reasonable assumption. Frequently, one is not interested in analyzing major increases or decreases in the level of defense activity during a short period of time. Rather, one is concerned with assessing the effect of marginal changes in growth rates. Then, provided the underlying increments of labor and capital are reasonably transferable among the three end uses of GNP, the aggregate model is as accurate as more detailed models. Also, there are sufficient uncertainties associated with both the location of defense production in the Soviet economy and the technology associated with this production that it may be difficult to specify a more detailed model.

¹GNP and Soviet defense burden data for 1985 are contained in *Gorbachev's Modernization Program: A Status Report*, a paper presented by the Central Intelligence Agency and the Defense Intelligence Agency for Submission to the Subcommittee on National Security Economics of the Joint Economic Committee, Congress of the United States, 19 March 1987. Investment and consumption's share of GNP, and the value of the civilian capital stock in 1985, are contained in *Handbook of Economic Statistics, 1987: A Reference Aid*, Central Intelligence Agency, CPAS 87-10001, September 1987. The labor force data to 2010 were obtained from the Bureau of the Census, and the median variant in their range of projections was used in this analysis.